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(54) Copper based alloy sheet material for electrical and electronic parts, having the effect of restraining wear of blanking die.

(57) A copper based alloy sheet material having an effect of restraining wear of a blanking die used to blank the same, which would occur during the blanking step, consists essentially of:
Ni: 0.5 - 3%,
Si: 0.08 - 0.8%,
Zn: 0.1 - 3%,
Sn: 0.1 - 0.9%,
Mg: 0.001 - 0.2%,
Mo: 0.0002 - 0.03%, and
Cu and inevitable impurities: the balance.

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BACKGROUND OF THE INVENTION

This invention relates to a copper based alloy sheet material for electrical and electronic parts which are manufactured by means of blanking, and more particularly to a copper based alloy sheet material of this kind, which has the effect of restraining wear of a blanking die used to blank the sheet material.

Various kinds of electrical and electronic parts such as leads of semiconductor devices, terminals and connectors are manufactured from copper based alloy sheet materials by a plurality of forming steps including a blanking step. Such electrical and electronic parts are generally required to possess satisfactory properties such as strength, elongation, springiness, electric conductivity, heat creep resistance, and heat solder-exfoliation resistance. Many copper based sheet materials, which satisfy these properties, have been used as materials for the manufacture of electrical and electronic parts, including one proposed by Japanese Provisional Patent Publication (Kokai) No. 63-76839.

However, in manufacturing various kinds of electrical and electronic parts from the conventional copper based alloy sheet materials, there is a problem that the blanking die used to blank the sheet material undergoes a considerable amount of wear during blanking, resulting in a short service life of the blanking die.

SUMMARY OF THE INVENTION

It is the object of the invention to provide a copper based alloy sheet material which does not cause a considerable amount of wear of a blanking die used in the manufacture of various kinds of electrical and electronic parts, to thereby contribute to prolongation of the service life of the blanking die.

To attain the above object, the present invention provides a copper based alloy sheet material having an effect of restraining wear of a blanking die used to blank the same, which consists essentially of:

Ni: 0.5 - 3%,
Si: 0.08 - 0.8%,
Zn: 0.1 - 3%,
Sn: 0.1 - 0.9%,
Mg: 0.001 - 0.2%,
Mo: 0.0002 - 0.03%, and
Cu and inevitable impurities: the balance.

The percentage throughout the specification is percent by weight.

The above and other objects, features, and advantages of the invention will become more apparent from the following detailed description.

DETAILED DESCRIPTION

Under the aforestated circumstances, the present inventors have made many studies in order to obtain a copper based alloy sheet material which causes wear of the blanking die to the least possible extent, while possessing satisfactory properties required of various kinds of electrical and electronic parts, and reached the following finding:

A copper based alloy sheet material, which consists essentially of:

Ni: 0.5 - 3%,
Si: 0.08 - 0.8%,
Zn: 0.1 - 3%,
Sn: 0.1 - 0.9%,
Mg: 0.001 - 0.2%,
Mo: 0.0002 - 0.03%, and
Cu and inevitable impurities: the balance, possesses excellent properties of strength, elongation, springiness, electric conductivity, heat creep resistance, and heat solder-exfoliation resistance, and also has an excellent effect of restraining wear of a blanking die used in the manufacture of the copper based alloy sheet material.

The present invention is based upon the above finding. The copper based alloy sheet material according to the invention has th aforementioned chemical composition.

The reasons for specifying as above the contents of the component elements of the copper based alloy sheet material according to the invention will now be described:

(a) Ni and Si:

These components are chemically combined to form a chemical compound which acts to enhance the strength and springiness of the copper based alloy sheet material without causing a large decrease in the electric conductivity, as well as increase the softening temperature and hence improve the creep resistance at high temperatures (heat creep resistance). However, if the Ni content is less than 0.5%, or if the Si content is less than 0.08%, the above chemical compound cannot be formed in a sufficient amount, whereas if the Ni content exceeds 3%, or if the Si content exceeds 0.8%, it will result in a degradation in the electric conductivity as well as in solder-exfoliation resistance at high temperatures (heat solder-exfoliation resistance). Therefore, the Ni and Si contents have been limited to ranges of 0.5 to 3% (Ni), and 0.08 to 0.8% (Si), respectively. Preferably, the Ni and Si contents should be 1.2 to 2.7% (Ni), and 0.2 to 0.7% (Si).

(b) Zn:

The Zn acts to enhance the solder-exfoliation resistance. However, if the Zn content is less than 0.1%, the solder-exfoliation resistance cannot be enhanced to a satisfactory level, whereas in excess of 3%, there will be a degradation in the electric conductivity. Therefore, the Zn content has been limited to a range of 0.1 to 3%, and preferably 0.3 to 1.7%.

(c) Sn:

The Sn acts to enhance the springiness. However, if the Sn content is below 0.1%, the springiness cannot be enhanced to a satisfactory extent, whereas if the Sn content exceeds 0.9%, it will cause a degradation in the electric conductivity. Therefore, the Sn content has been limited to a range of 0.1 to 0.9%, and preferably 0.2 to 0.7%.

(d) Mg:

The Mg acts to enhance the heat creep resistance as well as the heat solder-exfoliation resistance. However, if the Mg content is less than 0.001%, the above action cannot be performed to a desired extent, whereas if the Mg content exceeds 0.2%, the electric conductivity will be degraded. This is why the Mg content has been limited to a range of 0.001 to 0.2%, and preferably 0.003 to 0.08%.

(e) Mo:

The Mo is not solid-solved into the matrix, but most of the Mo is finely and evenly distributed in the crystal grain boundary. The fine Mo grains act to impart to the copper based alloy sheet material lubricity with respect to a blanking die during blanking operation by the use of the blanking die, to thereby greatly decrease the amount of wear of the inner surfaces of the blanking die and hence prolong the service life of the blanking die. However, if the Mo content is less than 0.0002%, the effect of restraining the wear of the blanking die cannot be exhibited to a desired extent, whereas if the Mo content exceeds 0.03%, it will result in insufficient elongation, and hence spoilage of the bending strength. Therefore, the Mo content has been limited to a range of 0.0002 to 0.03%, and preferably 0.0003 to 0.008%.

Next, an example of the copper based alloy sheet material according to the invention will be described.

EXAMPLE

Molten copper based alloys having chemical compositions shown in Tables 1 and 2 were prepared from a Ni-Mo alloy containing 1 to 20% Mo as a Mo source for obtaining homogeneous solving, by the use of an ordinary low-frequency channel-type smelting furnace. The prepared molten alloys were cast by a conventional semi-continuous casting method, into ingots, each having a size of 150mm in thickness, 400mm in width, and 1600mm in length. The ingots were hot rolled at a predetermined rolling-starting

SPECIMEN		CHEMICAL COMPOSITION (WT%)						
		Ni	Si	Zn	Sn	Mg	Mo	Cu+ IMPURITIES
COPPER BASED ALLOY SHEET MATERIALS ACCORDING TO PRESENT INVENTION	1	0.53	0.32	1.15	0.49	0.049	0.0051	BAL.
	2	1.73	0.43	1.17	0.51	0.048	0.0032	BAL.
	3	2.96	0.48	0.98	0.43	0.041	0.0041	BAL.
	4	1.82	0.082	0.97	0.48	0.048	0.0035	BAL.
	5	2.23	0.77	1.14	0.41	0.042	0.0043	BAL.
	6	2.11	0.45	0.12	0.47	0.044	0.0038	BAL.
	7	1.98	0.47	2.94	0.42	0.040	0.0045	BAL.
	8	1.95	0.41	0.97	0.11	0.043	0.0041	BAL.
	9	1.92	0.18	1.02	0.88	0.041	0.0047	BAL.
	10	2.04	0.44	1.10	0.45	0.0013	0.0044	BAL.
	11	2.03	0.47	1.04	0.42	0.190	0.0045	BAL.
	12	2.09	0.43	1.05	0.45	0.045	0.00022	BAL.
	13	1.95	0.46	1.01	0.47	0.044	0.0290	BAL.

TABLE 1

SPECIMEN		CHEMICAL COMPOSITION (WT%)						
		Ni	Si	Zn	Sn	Mg	Mo	Cu+ IMPURITIES
COMPARATIVE COPPER BASED ALLOY SHEET MATERIALS	1	0.37*	0.41	1.01	0.42	0.042	0.0043	BAL.
	2	3.25*	0.43	1.15	0.49	0.044	0.0038	BAL.
	3	1.97	0.062*	1.05	0.43	0.043	0.0039	BAL.
	4	2.04	1.03*	0.97	0.47	0.048	0.0045	BAL.
	5	2.13	0.47	0.07*	0.46	0.041	0.0041	BAL.
	6	2.16	0.40	3.34*	0.49	0.049	0.0047	BAL.
	7	1.94	0.43	1.07	0.06*	0.042	0.0044	BAL.
	8	2.12	0.42	1.12	1.03*	0.048	0.0042	BAL.
	9	1.94	0.41	0.94	0.42	- *	0.0036	BAL.
	10	2.15	0.42	1.08	0.49	0.29*	0.0035	BAL.
	11	1.92	0.43	1.04	0.42	0.043	- *	BAL.
	12	1.88	0.49	0.97	0.43	0.042	0.038*	BAL.

TABLE 2

temperature within a range of 750 to 900°C, into a hot rolled plate having a thickness of 11mm. The hot rolled plates were quenched, followed by each having its upper and lower side surfaces scalped by 0.5mm per each surface and its opposite lateral side surfaces by 3mm per each surface. The scalped plates were each repeatedly subjected to cold rolling and process annealing, into a cold rolled sheet having a thickness of 0.25mm. The cold rolled sheets were then subjected to annealing at a predetermined temperature of 250 to 550°C and for one hour, to obtain copper based alloy sheet materials Nos. 1 to 13 according to the present invention and comparative copper based alloy sheet materials Nos. 1 to 12.

The comparative copper based alloy sheet materials Nos. 1 to 12 each have the content of one of its component elements falling outside the range of the present invention, as asterisked in Table 2.

Then, a tensile test, a heat solder-exfoliation test, and a blanking die wear test w re conducted on the thus obtained copper based alloy sheet materials to measure the spring limit value (bending elastic limit) and the electric conductivity, and stress relaxation ratio for evaluation of the heat creep resistance.

In the tensile test, test pieces were picked off the copper based alloy sheet materials in a direction parallel with the rolling direction, and the tensile strength and elongation of the test pieces were measured to evaluate the strength.

The spring limit value was measured to evaluate the springiness by a moment test according to JIS H3130, by the use of test pieces having a size of 0.25mm in thickness, 10mm in width, and 80mm in length, which were picked off the copper based alloy sheet materials in a direction parallel with the rolling direction.

The electric conductivity was measured by a method according to JIS HO505 to evaluate the electric conductivity.

The stress relaxation ratio was measured to evaluate the heat creep resistance, under the following condition:

Test pieces having a size of 0.25mm in thickness, 12.7mm in width, and 120mm in length (hereinafter referred to as "L_0") . The test pieces were each set in a jig formed with a longitudinal groove having a length of 110mm and a depth of 3mm, in such a manner that the test piece was forcedly fitted in the groove horizontally disposed with its a central portion upwardly bulging (the distance = 110mm between the opposite ends of the test piece in this set state will be referred to as "L_1"). The test piece thus set in the jig was heated by soaking at 150°C for 1000 hours. After the heating, the test piece was removed from the jig, immediately followed by measuring the distance between the opposite ends of the test piece (hereinafter referred to as "L_2") in the hot state. Then, the stress relaxation ratio was calculated by the use of a formula $(L_0 - L_2)/(L_0 - L_1) \times 100\%$. If the stress relaxation ratio is smaller, it can be judged that the test piece has a smaller amount of deformation due to thermal stress over a long time (lower conformability), which means that it has more excellent heat creep resistance.

The heat solder exfoliation test was conducted under the following condition:

Test pieces having a thickness of 0.25mm, a width of 15mm, and a length of 60mm were treated with a rosin flux and then immersed in a solder bath of a 60% Sn - 40% Pb alloy at a temperature of 230°C so that the surfaces of the test pieces were plated with the solder. The solder-plated test pieces were heated in atmospheric air at a temperature of 150°C and for 1000 hours. After the heating, they were repeatedly bent flat on itself and bent back straight, followed by examining the presence of solder exfoliation at the bent portion to evaluate the heat solder-exfoliation resistance.

Further, the blanking die wear test was conducted under the following condition:

A blanking die formed of a WC based hard alloy having a composition of Co: 16% and the balance of WC was used, which is sold on the market. 700,000 circular chips with a diameter of 3mm were blanked from each of the copper based sheet materials. 20 chips immediately after the start of the blanking and 20 chips immediately before the end of the same were selected, the diameters of which were measured.

An amount of change in the diameter was determined from two average values of the respective groups of 20 chips to adopt it as the amount of wear. The amount of wear of a comparative copper based alloy sheet material No. 11 in Table 2, which has a composition corresponding to that of the conventional copper based alloy sheet material was set as a reference value of 1, and the wear amount of the other copper based alloy sheet materials were converted into values of a ratio relative to the reference value, as shown in Tables 3 and 4, to thereby evaluate the effect of restraining wear of the blanking die by the copper based alloy sheet materials.

SPECIMEN		TENSILE STRENGTH (N/mm²)	ELONGATION (%)	SPRING LIMIT VALUE (N/mm²)	ELECTRIC CONDUCTIVITY (IACS%)	STRESS RELAX. RATIO (%)	SOLDER EXFOLIATION	WEAR AMOUNT (RELATIVE RATIO)
COPPER BASED ALLOY SHEET MATERIALS ACCORDING TO PRESENT INVENTION	1	550	7	390	37	18	NIL	0.45
	2	575	8	430	46	12	NIL	0.52
	3	605	8	430	38	10	NIL	0.48
	4	540	6	380	36	17	NIL	0.50
	5	605	8	420	35	9	NIL	0.46
	6	580	8	420	44	11	NIL	0.51
	7	585	8	430	38	12	NIL	0.45
	8	565	7	375	53	12	NIL	0.46
	9	585	8	450	35	11	NIL	0.47
	10	575	8	420	46	17	NIL	0.46
	11	580	8	420	38	8	NIL	0.45
	12	575	8	420	43	11	NIL	0.65
	13	595	5	430	43	9	NIL	0.43

TABLE 3

SPECIMEN		TENSILE STRENGTH (N/mm²)	ELONGATION (%)	SPRING LIMIT VALUE (N/mm²)	ELECTRIC CONDUCTIVITY (IACS%)	STRESS RELAX. RATIO (%)	SOLDER EXFOLIATION	WEAR AMOUNT (RELATIVE RATIO)
COMPARATIVE COPPER BASED ALLOY SHEET MATERIALS	1	485	8	325	32	24	NIL	0.47
	2	605	8	440	32	9	NIL	0.53
	3	505	8	335	31	23	NIL	0.50
	4	595	7	440	27	9	PRESENT	0.46
	5	585	8	430	48	12	PRESENT	0.48
	6	585	8	430	32	11	NIL	0.48
	7	580	7	335	54	11	NIL	0.47
	8	590	8	460	31	10	NIL	0.46
	9	580	7	410	46	22	PRESENT	0.51
	10	595	7	430	32	8	NIL	0.53
	11	570	7	410	42	13	NIL	1.00
	12	595	3	420	45	9	NIL	0.43

TABLE 4

It will be learned from Tables 1 to 4 that as compared with the comparative copper based alloy sheet material No. 11 which does not contain Mo as an alloy component, the copper based alloy sheet materials Nos. 1 to 13 according to the present invention have much more excellent degrees of the effect of restraining wear of the blanking die, while possessing excellent strength, elongation, springiness, electric conductivity, heat creep resistance, and heat solder-exfoliation resistance, which are almost equivalent to those of the comparative copper based alloy sheet material No. 11. On the other hand, it is apparent from the tables that the comparative copper based alloy sheet materials Nos. 1 -12, of which at least one of the alloy components of the copper based alloy sheet material has a content falling outside the range of the present invention, are all inferior in at least one of the above-mentioned properties.

As described above, the copper based alloy sheet material according to the present invention possesses satisfactory properties required of various kinds of electrical and electronic parts, and at the

same time exhibits the effect of greatly restraining wear of the blanking die in the blanking step which is indispensable for the manufacture of the electrical and electronic parts, thereby prolonging the service life of the blanking die, and hence greatly contributing to reduction of the manufacturing cost and labour-saving.

Claims

1. A copper based alloy sheet material having an effect of restraining wear of a blanking die used to blank the same, which consists essentially of:
Ni: 0.5 - 3%,
Si: 0.08 - 0.8%,
Zn: 0.1 - 3%,
Sn: 0.1 - 0.9%,
Mg: 0.001 - 0.2%,
Mo: 0.0002 - 0.03%, and
Cu and inevitable impurities: the balance.

2. The copper based alloy sheet material as claimed in claim 1, consisting essentially of:
Ni: 1.2 - 2.7%,
Si: 0.2 - 0.7%,
Zn: 0.3 - 1.7%,
Sn: 0.2 - 0.7%,
Mg: 0.003 - 0.08%,
Mo: 0.0003 - 0.008%, and
Cu and inevitable impurities: the balance.

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EUROPEAN SEARCH REPORT

Application Number

EP 92 10 3249

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	DE-A-3 908 513 (MITSUBISHI SHINDOH CO.) * the whole document * ---	1,2	C22C9/06 C22C9/04
A	US-A-4 971 758 (SUZUKI ET AL.) * claims 1-12 * ---	1,2	
A	US-A-4 366 117 (TSUJI) * claims 1-3 * ---	1,2	
A	EP-A-0 189 637 (K.K.KOBE SEIKO) * claims 1-6 * -----	1,2	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 JUNE 1992	LIPPENS M.H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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